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NEW PRACTICE CASE STUDY 116

The Performance of a Variable Speed Air Compressor

Lewis & Towers Ltd, Edenbridge

- **Annual savings of £3,500**
- **Possible payback of under two years**
- **Provides precise pressure control**

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BACKGROUND

Lewis & Towers produce specialist glass containers, ranging from 30 ml pill bottles through to 5 litre Winchesters for chemical storage. The production environment is a dynamic one, with small batch runs requiring production changes on a daily basis.

A reliable source of compressed air is essential to the bottle blowing process, and the diverse range of products leads to variable air demands.

Lewis & Towers have a central compressor house from which air is distributed around the factory. In 1996 they became concerned about the adequacy of their compressed air system, which was causing them several problems because:

- The compressors were 18 years old and unreliable
- The air dryer was ineffective, allowing carry-over of water with the compressed air. This in turn was causing bottle defects and excessive wear to machinery mechanisms
- The main distribution pipework was too small leading to unstable and sometimes inadequate pressure at the production machines.

Lewis & Towers therefore decided to replace all their air compressors, the air dryer and key sections of the distribution main.

Their original intention was to install four, fixed speed rotary screw compressors and quotations were sought on this basis. One of the suppliers, however, proposed the use of a variable speed drive (VSD) compressor in place of one of the fixed speed machines. Whilst the VSD compressor would be more expensive, it was projected that the extra cost involved (£6,000), would be quickly recouped as the result of reduced electricity consumption. Lewis & Towers decided to adopt the recommended configuration of one variable speed and three fixed speed compressors.

THE COMPRESSORS USED AT LEWIS & TOWERS

Variable speed: CompAir BroomWade 475SR oil injected rotary screw compressor. Rated free air delivery: 430 cfm at 7 barg.

Fixed speed: CompAir BroomWade 6100N oil injected rotary screw compressors. Rated free air delivery: 477 cfm at 7 barg.

ENERGY SAVINGS FROM VARIABLE SPEED CONTROL

The fixed speed compressors installed at Lewis & Towers can be set to provide capacity control in one of two ways:

- On/off regulation: The compressor either operates ‘on load’ (delivering full air output) or ‘off load’ (delivering zero air output). If less than full output is required the compressor cycles alternately on and off-load in proportions necessary to deliver the required volume of air. In the off-load state the compressor continues to rotate and consumes approximately 30% of its full load electrical power. Should the compressor continue to operate off load for more than ten minutes (indicating a very low air demand), then it shuts down altogether and electrical consumption falls to zero.

- Inlet valve regulation: The compressor runs continuously, its capacity being regulated by a motorised valve which restricts the amount of air drawn through the inlet. This technique gives a more stable outlet pressure than on/off regulation, but below 90% load is significantly less energy efficient. At zero air delivery a compressor using inlet valve regulation will still consume around 65% of its full load power.

MULTI COMPRESSOR INSTALLATIONS

The alternative of using variable compressor speed to regulate output offers two significant advantages:

- Improved energy efficiency - a nearly linear turndown relationship is achieved between air delivered and power consumed.
- Closer control of output pressure - in addition to offering operability benefits, this also provides an additional energy saving of between 2-4% relative to on/off regulation.

The relationships between air delivered and power consumed for the three methods of regulation are shown graphically in Figure 1. It can be seen that although a VSD compressor consumes slightly more power than a fixed speed machine at high loads (due to electrical losses in the variable speed drive), under all other conditions it is much more efficient. The lower the percentage loading, the greater the savings.

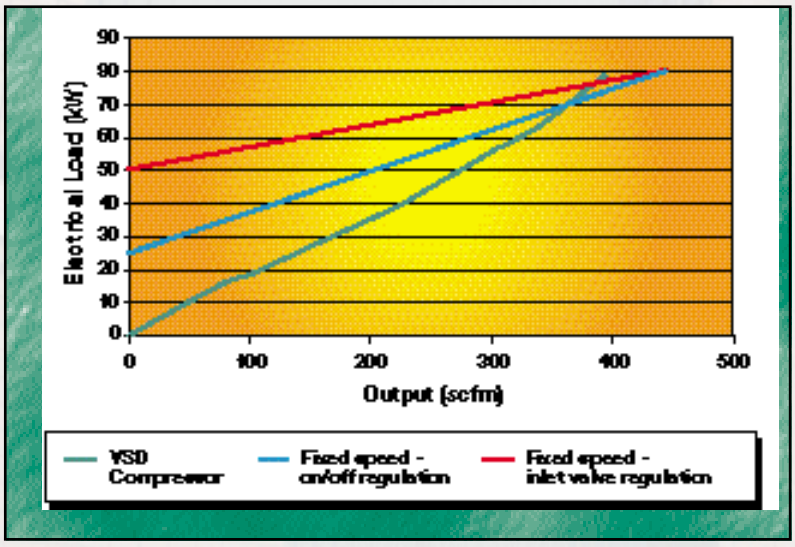


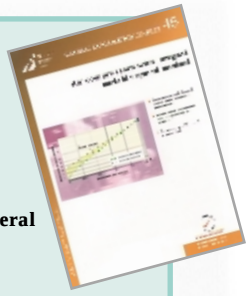
Fig 1 - Comparison of Compressor Performance

MULTIPLE COMPRESSOR INSTALLATIONS

In installations with more than one compressor, only one needs to be a VSD machine. Fixed speed compressors (which are cheaper and more efficient at full load) should be used to provide a base load, leaving the VSD machine to 'top up' as required by changes in demand. Lewis & Towers operate in this way and as their normal air demand is always somewhere between the output of 2-3 compressors they are able to adopt a very simple control strategy.

Two of their fixed speed compressors are set to come on load when system air pressure falls below 6 barg and go off load when it rises above 6.4 barg (the third fixed speed compressor is left off-line as a standby). The VSD compressor is set to control at 5.6 barg, which is the required system operating pressure. This arrangement ensures that the fixed speed compressors run continuously at full load, leaving the VSD machine to modulate.

In applications where air demands are more variable than at Lewis & Towers, it will be necessary to install a sequence controller to step successive fixed speed compressors in or out of service in order to maintain the VSD machine within its modulating range.



Further information on the principles and benefits of using variable speed air compressors is given in General Information Leaflet 45. Copies are available free of charge from the Energy Efficiency Enquires Bureau.
Tel: 01235 436747 or Fax: 01235 433066.

MONITORED PERFORMANCE

Independent monitoring was undertaken to confirm the operating characteristics and energy savings resulting from the use of the VSD compressor at Lewis & Towers.

The monitoring comprised of:

- BS1571 tests to confirm the performance of each compressor
- Monitoring of total air demand and compressor electricity consumption over a two week period in order to characterise Lewis & Towers' air consumption profile and confirm the corresponding operation of the three air compressors.

SAVINGS

The results for the BS1571 tests formed the basis of the data shown in Figure 1. They also revealed that one of the fixed speed compressors was faulty and only delivering 82% of its rated capacity (equivalent to a shortfall of 78 scfm at normal system operating pressure). The fault was later traced to the inlet valve and has now been rectified.

The monitoring confirmed that two fixed speed compressors had run continuously at full capacity to provide a base load, whilst the VSD machine had modulated correctly to 'top up'. Figure 2 shows how closely the electrical load of the variable speed compressor mirrored changes in the system air demand.

Over the two-week monitoring period, the average load on the VSD compressor was 313 scfm (79% of full capacity). This load was artificially high due to the low output of the faulty fixed-speed machine. Had this been working properly, the average load on the VSD compressor would have dropped to 235 scfm (59% of full capacity).

SAVINGS

Based on the 'as found' conditions, i.e. with the faulty fixed speed compressor, the use of the VSD compressor at Lewis & Towers is saving them around 31,200 kWh/year of electricity (relative to the alternative of a fixed speed machine with on/off capacity regulation). This saving is worth around £1,750 per year, giving a payback on the £6,000 extra cost for VSD of 3.4 years.

However, had all the fixed-speed air compressors been working correctly, then the annual saving would have been higher at 83,100 kWh. This would have been worth around £3,530 per year, reducing the payback period to a more realistic 1.7 years.

CONCLUSIONS

The results from Lewis & Towers show how the economics of installing a VSD compressor are heavily influenced by its average load. As illustrated in Figure 3, the lower the average load, the larger the savings relative to a fixed speed machine.

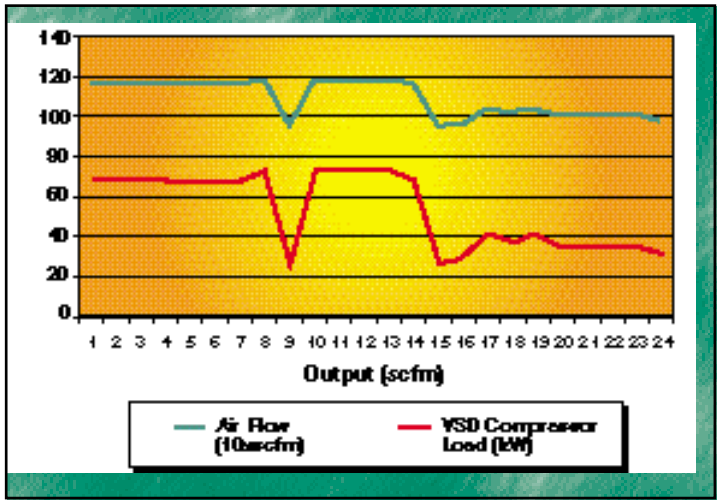


Fig 2 - Air Demand and VSD Electrical Load Profiles, 20/7/98

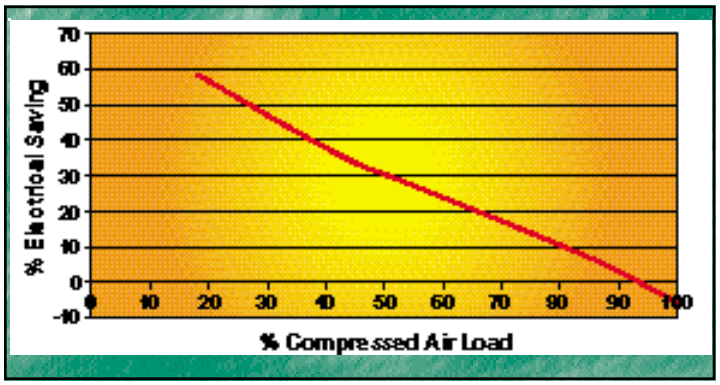


Fig 3 - Saving vs VSD Compressor Load

VSD compressors are therefore most applicable to sites which have occasional peaks in air demand, but which normally have much lower loads. They can also be useful for providing flexibility for future expansions in air demand, without incurring the low load inefficiencies normally associated with over-sized plant.

Under the right circumstances the payback of the incremental extra cost of a VSD compressor can be under two years.

Lewis & Towers have found their VSD compressor to be reliable and it requires no more maintenance than their fixed-speed machines.

HOST ORGANISATIONS

"At Lewis and Towers we recognise that we need to be innovative if we are to remain competitive. Above all the plant and equipment that we install must be reliable and cost effective.

Our new compressor installation meets these criteria and has transformed operations in the factory. We are now able to operate processes that would have been impossible with the poor quality air produced by our old plant.

The variable speed compressor is a key component of this improvement and its extra cost has been more than justified by the benefits of precise pressure control and energy savings"

Graham Hayes, Works Director

"Compressed air used to be a major maintenance headache for us. Not only were our compressors unreliable, but large pressure swings and air contaminated with oil and water caused problems on our production machinery.

Since the installation of the new compressors and their associated air dryer, all this has changed. Compressed air is no longer a problem area for us.

The variable speed compressor has proved to be totally reliable - in fact the only malfunction we have had was on one of the fixed speed machines.

If there has been a down side, it's that we've had to increase the lubrication frequency for some of our air operated actuators - in the past the oil carried over in the compressed air did the job for us!"

Philip Freeman, Plant Engineer

This project was monitored independently by: Briar Associates. Tel: 01384 79333.

ASSESSING YOUR AVERAGE AIR DEMAND

ASSESSING YOUR AVERAGE AIR DEMAND

As this case study shows, a good understanding of your factory's compressed air demand is important when assessing the viability of using a VSD compressor.

This information can often be obtained from your existing compressor installation by using simple techniques such as:

- Observing the pattern of on load/off load operation
- Recording the electrical power consumed.

Additionally, this approach can give you a valuable insight into other aspects of your compressed air system such as leakage levels, 'out of hours' usage etc.

Further guidance on these techniques is contained in Good Practice Guide 126, Compressing air costs. Copies are available free of charge from the Energy Efficiency Enquires Bureau.

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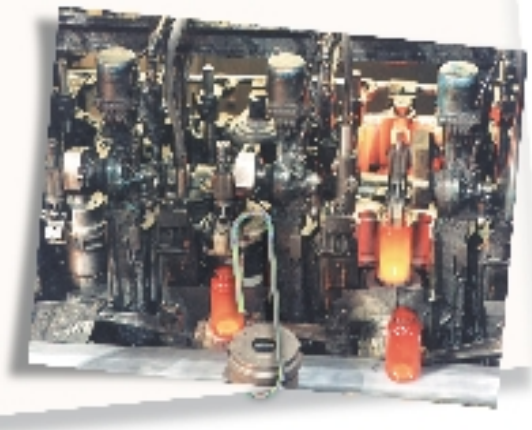

WASTE HEAT RECOVERY

The air compressors at Lewis & Towers are air cooled and the hot air produced has to be ducted away to prevent overheating within the compressor house.

Lewis & Towers have invested in additional dampers and ductwork to enable the hot air to be diverted into a neighbouring warehouse in winter, thereby reducing the need for other forms of heating. The modifications cost only a few hundred pounds and should pay for themselves within one heating season.

Further information on heat recovery from air compressors is given in Good Practice Guide 238, available free of charge from the Energy Efficiency Enquiries Bureau, tel 01235 436747 or fax 01235 433066.